THE HISTORY OF BYZANTINE SCIENCE

Report on the Dumbarton Oaks Symposium of 1961

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THE symposium of 1961 was dedicated to the history of Byzantine Science and was directed by the present writer, who contributed two papers dealing respectively with "The Byzantine Concept of Science" and "Byzantine Training in the Sciences." On the basis of an analysis of the Aristotelian concept of science (ἐπιστήμη) and its mediaeval history, he showed that Byzantine science was in every period closely connected with pagan philosophy and metaphysics. On this account, it might have been expected that narrow-minded ecclesiastics would have objected to this field of study, as some in fact did. But the opposition to pagan learning was not widely supported, and many of the most distinguished classical scholars held high office in the Church.

Consequently, anti-intellectualism was never characteristic of the Byzantine Church as a whole, although there were a few outbreaks of this timeless malady which cannot be ignored. The most noteworthy of these include the savage murder of Hypatia, the pagan mathematician and astronomer (which was instigated, some sources say, by Archbishop Cyril of Alexandria, d. 444), the obscurantism of Cosmas Indicopleustes (*ca.* 550), and the condemnation of Johannes Italus (1082) because of his devotion to ancient philosophy.

Despite a few incidents of this kind, the pagan writings of antiquity never ceased to be cultivated in Byzantium. This happy circumstance is largely to be ascribed to the impetus given to classical studies by the University of Athens in the fourth and fifth centuries, the vigor of the philosophical academy of Alexandria during the first six centuries, and, above all, to the long and honorable services performed by the imperial University of Constantinople, which was founded in 425 or, perhaps, originally in the time of Constantine I. This university, which underwent numerous reorganizations in the course of its history, concerned itself entirely with secular subjects, to the exclusion of theology, which was taught in the Patriarchal Academy.

But even the latter offered instruction in the ancient classics and did not fail to include literary, philosophical, and scientific texts in its curriculum. The monastic schools, however, concentrated upon the Bible, theology, and the liturgy. As a result of this division of interest, the monastic scriptoria expended most of their efforts upon the transcription of ecclesiastical manuscripts, while pagan literature was transcribed, summarized, excerpted, and annotated by laymen or enlightened bishops like Photius, Arethas, Eustathius of Thessalonike, and Bessarion.

Robert Van Nice ("Evidence of Applied Science in the Structure of Hagia Sophia") demonstrated that little evidence of applied science is discernible in the variety of arched and spherical forms that enclose the nave of the "Great Church." Among the twelve arches of five different kinds that carry the central dome, the two large semidomes, and the four semidomes of the exedrae, there appears to be no consistent relationship between span, thickness, and loading which would suggest the application of formalized rules of construction resulting from the codification of previous experience. The semidomes, on the other hand, which have long been interpreted as major supports of the dome, seem to reveal intuitive, if not scientific, understanding of the principle of modern engineering theory that semidomes play no effective role in countering the radial forces exerted by the dome.

Having determined for the first time the precise contours of the semidomes in Hagia Sophia, Van Nice finds that the order of magnitude of their thickness is the reverse of what it would have been had Justinian's

architects intended them to resist cumulative thrusts originating in the main dome. For the shell of the central dome is thicker than that of the two large semidomes, and the shells of the semidomes in the exedrae the thinnest of the three. It seems certain, therefore, that the semidomes were originally conceived, not as structural elements, but solely as forms designed to enhance the spatial effect of the nave.

Harry A. Wolfson ("The Problem of the Inner Movers of the Spheres in the Byzantine Commentaries upon Aristotle, and its History," printed *supra*), discussed the question as to whether, in Aristotelian physics, the celestial bodies may be said to have souls. It was generally agreed by the Byzantine commentators and their successors that the celestial bodies had rational souls, but there was a difference of opinion as to whether these bodies possessed the faculty of sensation.

O. Neugebauer ("On Byzantine Astronomy") commented upon the use of zero in Greek papyri, and described the Ptolemaic theory of epicycles. He concentrated upon the Ptolemaic concept of the universe because it dominated the whole of mediaeval astronomy, in both the East and the West. He laid emphasis also upon the immense services rendered by Byzantine scholars in transmitting the results of ancient astronomical research, and concluded that some among them, though not distinguished for originality, were respectable astronomers.

Aubrey Diller spoke on "The Byzantine Contribution to Geography." In the early centuries Byzantine merchants and sailors pushed south into Africa and may even have reached India. In the tenth century, contact was established with Russia. But subsequently, especially as a result of the Latin conquest, the Byzantines lacked the strength, as well as the interest, to participate in the exploration of the Mongolian Empire.

Except for Georgius Gemistus Pletho (*ca.* 1355–1452), who wrote a treatise on geography and compiled a large collection of excerpts from Strabo, most of the Byzantine writers on geography flourished before the end of the tenth century. The most interesting among them were Stephanus Byzantius (? fifth century), Cosmas Indicopleustes and Hierocles (both of the sixth century), and the scholar-emperor Constantine VII (Emperor, 913–959), who edited the *De thematibus* and *De administrando imperio*. The greatest service performed by Byzantium in this field was the preservation of the geographical works of Strabo and Ptolemy, the former of which (τὰ γεωγραφικά) was known and utilized in the Byzantine Empire from the sixth century on. The latter and more difficult of the two, the Γεωγραφικὴ ὑφήγησις, lacks the descriptive material which makes Strabo an indispensable encyclopaedia of classical lore, and is given over almost entirely to tables of co-ordinates intended to be used by cartographers. It was known in the ninth century and rediscovered *ca.* 1300 by Maximus Planudes, who constructed the maps now preserved in the extant codices.

Marshall Clagett ("The Byzantine Influence on Mediaeval Latin Mathematics and Mathematical Physics") showed that, prior to the twelfth century, the West derived from Byzantine mathematicians only a few fragments of Euclid in Greek and some vague references to Archimedean ideas of density. In the twelfth century, and the early part of the thirteenth, the Latin West acquired most of its knowledge of Greek mathematics from translations of Arabic versions of the Greek texts, and made only a few efforts in the direction of rendering the Greek texts themselves into Latin.

On the other hand, certain translations were made from the original Greek, like the *De canonio*, a late Greek or early Byzantine text on statics. The *De curvis superficiebus*, however, attributed to Archimedes, was actually composed in Latin, perhaps on the basis of some Greek text, by Johannes de Tinemue (fl. 1260). As the thirteenth century advanced, direct contact with Greek sources increased, notably through the strenuous efforts of William of Moerbeke, who manifested an extraordinary range and versatility as a translator of many types of text, including a major portion of the works of Archimedes.

In his lecture, "Byzantine Medicine: Tradition and Empiricism," printed *supra*, Owsei Temkin distinguished the developments that took place before 642, the year of the Arab capture of Alexandria, from those of the subsequent centuries down to 1453.

Lynn Thorndike then expounded upon "Relations between Science and Pseudo-science in Byzantium and the West before 1350." He analyzed briefly the relevant works of the principal Greek and Latin writers who dealt with science, astrology, and magic, and compared them from the point of view of method and technique.

Certain general conclusions emerged from the discussion. The meager accomplishment of the Byzantines in the natural sciences remains one of the mysteries of the Greek Middle Ages. Assuming the great importance of the ancient Greek classics and their significance for modern culture, historians find it difficult to explain why the Renaissance was so long delayed. How did it come about, many have asked, that the Byzantine Greeks were unable to build upon the ancient learning and use it as the basis for new discoveries?

The answer to this question cannot easily be given. But it should not be assumed that the Byzantines were altogether unimaginative or completely unworthy of attention in the history of science. They attained significant results in many areas, especially in the construction of city walls, in ecclesiastical architecture, in the production of the mysterious "Greek fire" (the prototype of modern gunpowder), and in an ingenious use of the automata of Hero of Alexandria (*ca.* 62 of the Christian era) to produce the miraculous singing birds, roaring lions, and rising throne, which mystified and enchanted visitors to Constantinople.

Moreover, on a somewhat higher plane, John Philoponus, in the sixth century, made a significant advance by rejecting the Aristotelian notion that it was impossible to produce a vacuum. He also anticipated Galileo's experiment which proved that weights dropped from the same height will reach the ground at approximately the same time, and that their speed of descent does not depend upon the ratio of their weights. Eight hundred years later, in another field, the polymath Nicephorus Gregoras, among others, made studies of the length of the year which enabled him to propose suggestions for a reform of the Julian calendar, very much like that introduced by Pope Gregory XIII in 1582. Then, most significantly, at the end of the Byzantine period Pletho introduced the Geography of Strabo to the Latin West, and thus exerted an important influence upon the geographical theory of the Renaissance, which was one of the contributing factors leading to the discovery of America by Christopher Columbus in 1492.

Taken all in all, these were no mean achievements. Byzantine science would undoubtedly have reached even greater heights, had it not been for the debilitating force of traditionalism. This conservative instinct manifested itself most markedly in political theory and theology, in the realm of both of which the overpowering and stultifying effect of authority precluded freedom of thought or inquiry. Very similar in effect was the passionate and almost worshipful devotion to the classics, which were revered as the national heritage and, as such, deemed to be beyond criticism. In this environment, radical departures from the conclusions of the ancient sages were hardly to be expected. Usually, though by no means invariably, as the criticism of Aristotle by John Philoponus and other commentators demonstrates, the results and data compiled by ancient scientists were repeated without independent verification. This tendency is characteristic of Byzantine writers in general, who customarily reproduced their sources verbatim, without conscious intent to plagiarize.

In their respective domains, the Oecumenical Creeds, the decrees of the emperor, and the ancient classics were treated with deference and even with obsequiousness. They were meant to be understood and, on occasion, suitably annotated. But they were beyond the reach of criticism, and, except when they gave utterance to pagan religious beliefs, could not be disputed or overridden. These limitations inevitably stifled originality, and led to a certain amount of intellectual rigidity, against which only the most adventurous spirits ever dared to rebel. Nevertheless, we should not be hypercritical of this habit of mind. For it is in part this very attitude that inspired the Byzantines to transcribe the ancient classics and so to transmit them to posterity.*

* Bibliographical references can be found *in extenso* in the present writer's forthcoming book, *The Mind of Byzantium*, and in the works of the scholars whose lectures are here summarized.